CLAIMS

1   1. A transient temperature control system for preventing collisions during a transient

2   cool-down temperature range of a free piston cooler from a first operating temperature of

3   a cold head to a set point operating temperature, the cooler having a piston reciprocating

4   in linear oscillation within a cylinder at a variable stroke, the system comprising:

5   (a) a cold head temperature sensor for sensing the temperature of the cold head

6   and generating a temperature signal;

7   (b) a relational interface in communication with the temperature signal and

8   containing a predetermined relationship between the cold head temperature and a

9   maximum piston stroke during the transient cool-down temperature range, the

10   relational interface generating a transient range maximum allowable stroke signal

11   from the temperature signal and the predetermined relationship; and

12   (c) a temperature controller in communication with the relational interface,

13   capable of receiving the transient range maximum allowable stroke signal and

14   limiting the stroke to prevent collisions within the cooler during the transient

15   cool-down temperature range, and capable of controlling the stroke of the piston

16   while the cold head operates at approximately a steady state cold head

17   temperature.

1   2. The control system in accordance with claim 1, wherein the predetermined

2   relationship between the cold head temperature and the stroke comprises a plurality of

3   stored data experimentally determined by operating the cooler during the transient cool-

4   down temperature range, and recording the stroke resulting in collision at a plurality of

5   cold head temperatures and generating a transient controlled stroke by applying a stroke

6   reduction factor to the collision stroke.

1   3. The control system in accordance with claim 2, wherein the plurality of stored data are

2   resident in a table form for reference by the relational interface in generating the transient

3   range maximum allowable stroke signal.

1   4. The control system in accordance with claim 2, wherein the plurality of stored data

2   are resident as a stored algorithm for reference by the relational interface in generating

3   the transient range maximum allowable stroke signal.

1   5. A method for preventing collisions during a transient cool-down temperature range of

2   a free piston cooler from a first operating temperature of a cold head to a set point

3   operating temperature, the cooler having a piston reciprocating in linear oscillation within

4   a cylinder at a variable stroke, the method comprising:

5   (a) sensing the temperature of the cold head and generating a temperature signal;

6   (b) generating a transient range maximum allowable stroke signal in response to

7   the temperature signal and a predetermined relationship between the cold head

8   temperature and a maximum piston stroke during the transient cool-down

9   temperature range; and

10   (c) limiting the stroke of the piston during the transient cool-down temperature

11   range, to prevent collisions within the cooler, in response to the transient range

12   maximum allowable stroke signal.

1   6. The method in accordance with claim 5, further including the step of experimentally

2   developing the predetermined relationship between the cold head temperature and the

3   stroke by operating the cooler during the transient cool-down temperature range, and

4   recording the stroke resulting in collision at a plurality of cold head temperatures and

5   generating a transient controlled stroke by applying a stroke reduction factor to collision

6   stroke.

1   7. The method in accordance with claim 6, further including the step of referencing an

2   electronic database, having the predetermined relationship between the cold head

3   temperature and the stroke, when generating the transient range maximum allowable

4   stroke signal.

1   8. The method in accordance with claim 6, further including the step of referencing an

2   algorithm, having the predetermined relationship between the cold head temperature and

3   the stroke, when generating the transient range maximum allowable stroke signal.

1   9. An apparatus for preventing collisions during a transient cool-down temperature range

2   of a free piston cooler from a first operating temperature of a cold head to a set point

3   operating temperature, the cooler having a piston reciprocating in linear oscillation within

4   a cylinder at a variable stroke, the apparatus comprising:

5   (a) a means for sensing the temperature of the cold head and generating a

6   temperature signal;

7   (b) a means for generating a transient range maximum allowable stroke signal

8   from the temperature signal and a predetermined relationship between the cold

9   head temperature and a maximum piston stroke during the transient cool-down

10   temperature range; and

11   (c) a means for controlling the stroke of the piston during the transient cool-down

12   temperature range, to prevent collisions within the cooler, from the transient range

13   maximum allowable stroke signal, and controlling the stroke of the piston during

14   approximately steady state cold head temperature conditions to prevent collisions

15   within the cooler.

1   10.   The apparatus in accordance with claim 9, wherein the predetermined relationship

2   between the cold head temperature and the stroke comprises a plurality of stored data

3   experimentally determined by operating the cooler during the transient cool-down

4   temperature range, and recording the stroke resulting in collision at a plurality of cold

5   head temperatures and generating a transient controlled stroke by applying a stroke

6   reduction factor to the collision stroke.

7   11.   The apparatus in accordance with claim 10, wherein the plurality of stored data

8   are resident in a table form for reference by the generating means in generating the

9   transient range maximum allowable stroke signal.

10   12.   The control system in accordance with claim 10, wherein the plurality of stored

11   data are resident as a stored algorithm for reference by the generating means in

12   generating   the   transient   range   maximum   allowable   stroke   signal.